Renewable and Sustainable Energy Reviews 14 (2010) 1342–1346

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Implementation of PV plants in Spain: A case study

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ARTICLE INFO

Article history:
Received 1 December 2009
Accepted 1 December 2009

Keywords:
PV grid-connected systems
PV production
PV support
Administrative process

ABSTRACT

The implementation process of a photovoltaic system and its connection to the national grid in Spain is examined from an economic, an administrative and a legal standpoint. In the first place, this case study describes the solar farm, and it goes on to examine the economic aspects of electricity production, its associated costs, and relevant grants and financial subsidies. Finally, problems related to the administration of the project and the issuing of permits by local and regional authorities are discussed.

Contents

1. Introduction

Increasing emphasis in modern-day society is placed on the use of renewable energy resources and improvements to the performance of the electricity generation system. These are basic principles in order to coordinate sustainable development from an economic, social and environmental viewpoint. The Spanish energy system is characterized by its high dependence on imports: 80% of energy consumption is from imported sources. On August 26, 2005, the Spanish government approved the Renewable Energy Plan 2005–2010 [1] (Plan de Energías Renovables, PER). Its overall aim is to meet the target of supplying 12% of Spain's primary energy needs and 30% of its demand for electricity from renewable sources by 2010. The European Commission (COM (2008) 0019) [2] set a binding target of 20% of total consumption from renewable energy sources by 2020.

The most important solar resources in Europe are to be found in Spain. Global solar irradiation on a horizontal plane is estimated at between 1.48 and 3.56 kW/m^{2}day in Spain [3]. Solar photovoltaic energy is an irreplaceable technology to achieve the proposed environmental and economic objectives. Additional aspects, such as continual lowering of costs and prices in most system components, institutional economic support, versatility and modularity, and minimum maintenance cost, mean that installed PV power in Spain is estimated to rise to 3000 MW by the end 2009, with more than 14,000 grid-connected systems. [4]

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1364-0321/$ – see front matter
doi:10.1016/j.rser.2009.12.010

In August 2008, Castilla y León was the second Spanish autonomous region in terms of PV energy, with 215 MW of installed power, second only to Castilla La Mancha, with 402 MW [5]. The geographical and meteorological characteristics of the region favor the construction of "solar farms" to exploit solar energy: large plains with high levels of solar insolation, very few cloudy days and moderate ambient temperatures. About 70 companies in the region are active in the PV industry. They generate a turnover of €500 million and account for 1300 jobs [5]. Investment profitability should therefore become a priority both for the Administration and for the companies involved in this business sector.

2. Legal framework of the PV Spanish market

The case study proposed in this paper is a grid-connected PV installation formed by nine facilities, each of 100 kW. The project was initiated in January 2005, although the definitive launch of the plant took place in April 2008. At that time, grid connected PV installations were regulated by Royal Decree (RD) 436/2004 [6]. It provides incentives for newly capacity of renewable energies. For PV grid-connected facilities, generators which sell their production to a distributor, receive a fixed tariff, defined as a percentage of a regulated tariff. The percentage was established on a technology-by-technology basis [7]. The regulated tariff for 2004 has been established as 0.44 €/kWh.

On May 25, a new RD 661/2007 [8] was published, which regulated the production of electricity under the special regime. It established new energy tariffs from 1 June 2007 with a feed-in-tariff system for 25 years, as from 2007. The tariff system is shown in Table 1. The tariffs will be updated each year according to the CPI until 2012. A transitory regime has been established for certain installations. In this case study, it is subject to the tariff scheme shown in Table 1.

3. PV system description

The "solar farm" case study is located in Astudillo (Palencia), at the centre of the autonomous region of Castilla y León in Spain. The plot occupies 7000 m^2 of which about half is occupied by the solar panels. It is south facing and on a slight slope that favors natural air circulation, one of the most beneficial aspects for improving the panels' electrical production in summer time. The area has very good atmospheric conditions. Solar irradiation is estimated to be about 1450 kWh/m^2year. The ambient temperature range is between 4 °C and 20 °C and the number of cloudy days is very low. A 120 m^2 surface building has been built, which, on the first floor, houses a science centre to educate the public about solar energy. The inverters, transformation centre (T.C.) and measurement equipment are in the basement of this building. Fig. 1 shows an aerial photograph of the installation.

The "solar farm" has nine 100 kW installations: eight of which of 98.6 kWp and the ninth, 100.98 kWp. It has a total of 5038 PV panels. Nine 160 KVA electrical transformers, one for each facility, and an additional 50 KVA for plant consumption make up the T.C., which are connected to the protection and measurement system, in accordance with the specifications of the distributing company. All Spanish low voltage electro-technical regulation [9] requirements are carried out by the plant. Individualized protection systems are designed for easy routine maintenance. Fig. 2 shows one of the protection boxes. An interesting feature of the plant is the panel support system. A mobile structure has been designed which allows the position of the panels to vary throughout the year, to optimize electrical production. This system helps integrate the facilities into the environment, virtually without visual impact [10]. The maximum height of the panels (1.80 m) is usually at winter and they can be lowered at other times of the year. Fig. 3 shows the panel support system and Fig. 4 shows their maximum and minimum positions.

Table 1
Feed-in tariff system in Spain as laid down by Royal Decree 661/2007 [8].

Power (kW)		Tariff (cent €/kWh)
P≤100 kW	First 25 years	44.0381
	After which	35.2305
100 kW<P≤10 MW	First 25 years	41.7500
	After which	33.4000
10<P≤50 MW	First 25 years	22.9764
	After which	18.3811

Fig. 1. Aerial photograph of the Astudillo PV installation.

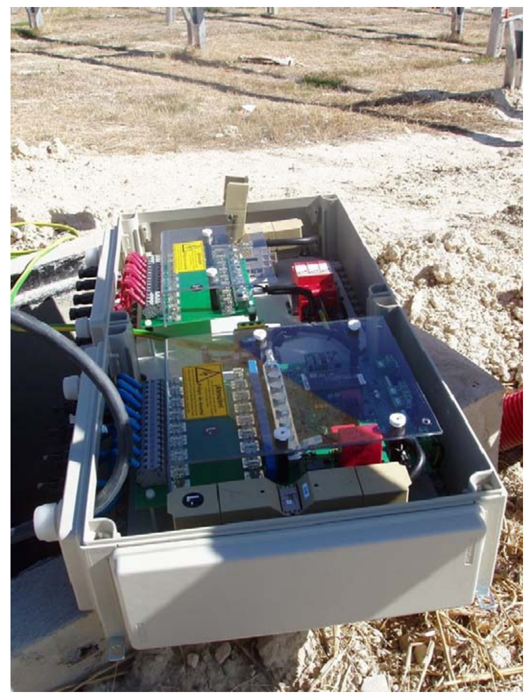

Fig. 2. View of an electrical protection box. There are three individualized boxes for each of the 100 kW facilities.

4. Cost and production

Costs have to include a list of items which are quite essential in themselves, but have no direct connection to the project. Execution of the work implies costing the following elements that make up the overall budget: plot acquisition, fencing, geological survey,

Fig. 3. Panel support system: enables the adjustment of the panel throughout the year.

Fig. 4. Comparison between maximum and minimum panel incline.

panels, support system, electrical installation, surveillance systems, electrical protection systems, inverters, measurement equipments, transformation centre (T.C.), project engineering, certification bodies, local and regional administrative fees and manpower.

Costs incurred due to administrative delays in the start up of plant services must be added to the project costs. Such delays may impact on debt repayment schedules to finance the solar farm. Additional technical problems, in this case study, led to the obligatory replacement of the power distribution line, which meant extending the implementation of the project by 2 years.

The final price of each facility amounted to €800,000, which includes a pro-rata share of extrinsic costs.

The installation began to function towards the end of April 2008. To date, it has functioned at full capacity without any total stoppages at any of the facilities, and only minor incidents which have resulted in short-term losses in production.

Fig. 5 shows production at one of the facilities in January 2009. A total amount of 5758 kWh/month, slightly higher than the estimated value of 5625 kWh/month, was registered.

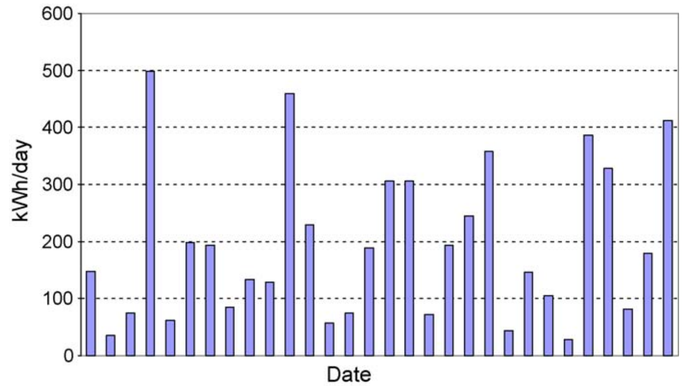

Fig. 5. Production at a 100 kW installation in January 2009.

Solar farm production, from the beginning of the activity to date (August 30), has been 1296 MWh, which amounts to €930,000. These figures mean, for a total plant cost of about €7.2 million, a total repayment period of eight years, after making allowance for financial subsidies and grants. Fig. 6 shows total production for each of the solar farm installations.

5. PV support measures. Grants and financial support

The project began in January 2005, at a very propitious time for the implementation of PV installations when there were direct capital subsidies for grid-connected plants, managed though the ICO (Instituto de Crédito Oficial).

The draft projects for the eight installations were presented to the Instituto de la Diversificación y Ahorro Energético (IDAE) in June 2005. They ninth facility, however, failed to meet the conditions for receiving the grant [11]. The applications have to include previously negotiated agreements with banks collaborating with the ICO. The banks were in charge of granting the loan, which could not exceed 80% of the total budget for each installation. It was also necessary to include an agreement with the bank that stipulated a commitment to comply by the deadline for repaying the loan and an execution time. A descriptive report of the installation also had to be attached to complete the application [11]. A grant amounting to €357,600 was finally awarded in September 2005.

6. Legal framework and administration

The administrative process was long and drawn out due to the need to acquire various permits and a degree of unwillingness and even ignorance on the part of local and regional authorities. Processing the necessary licenses to operate a PV plant entails contact with three administrative layers at a local, provincial and autonomous level. The same process can have different outcomes within the same autonomous region, due solely to the administrative staff's particular interpretation of legislation.

It can take several years from the moment that a consortium decides to enter the business of PV energy production up until the grid connection of the installation and the definitive start up of the service. The first step is to ask the electricity distribution company in the area for a "connection point". This process should be resolved within a maximum period of thirty days, which is usually not the case.

Having established the connection point, the specifications for evacuation of power to the network are drawn up. These are often complex, sometimes excessive and could even be called dissuasive. Once these specifications are accepted, the project management team has to request a provisional special regime for the production

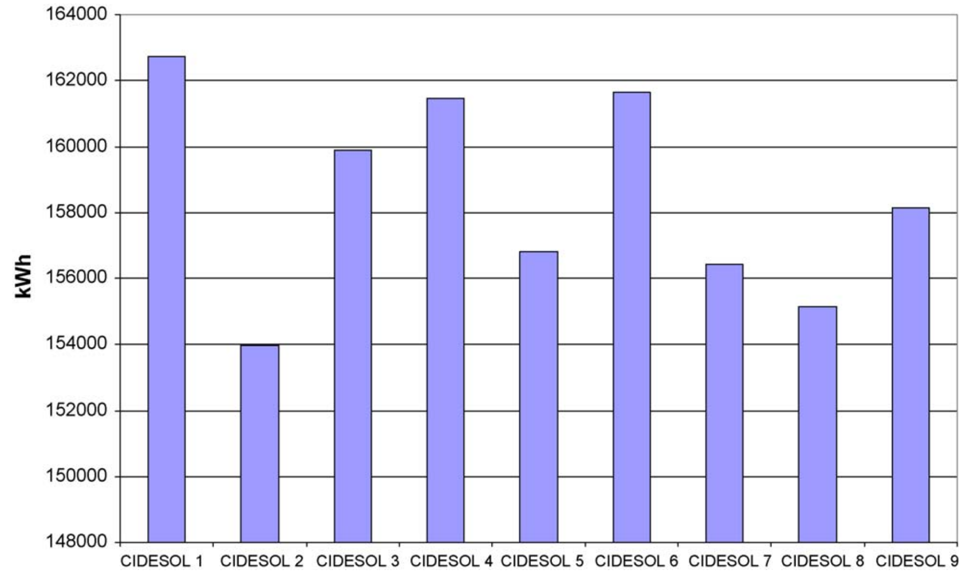

Fig. 6. Accumulated production for each one of the installations at the solar farm.

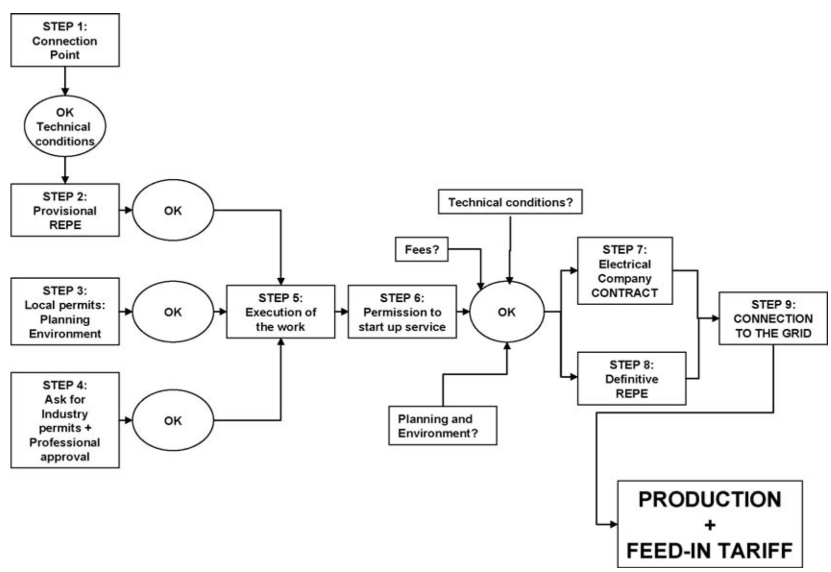

Fig. 7. Schematic diagram of the necessary administrative procedures prior to the start up of a PV installation in Castilla y León, Spain.

of electricity (*Regimen Especial de Producción de Electricidad—REPE*). The amount of detailed information required for this procedure is excessive and, in most cases, the process is all too lengthy. After a period of between two and six months, the provisional REPE that is only valid for a period of 12 months is issued.

Together with the REPE application, a license has to be obtained from the local council. This license involves obtaining two permits that are issued by the provincial administration, and require the approval of the Planning and Environment Committee. Both permits are usually issued after 4 months, although they may be simultaneously processed.

In the meantime, the administrative license must be obtained from the provincial delegation of the Autonomic Secretariat of Industry, which requires a draft by a competent technician and the approval of the Professional Association. The time required to process this permit, which is needed to begin the work, depends on application date and location, but it is invariably over one month. The same process must be repeated for the project to connect the installation to the grid, which is independent of the PV plant.

Once the PV installation and the line connection to the network are complete, a completion permit is signed off for each of the facilities. A company accredited by the regional administration certifies the basic specifications and the corresponding specifications resulting from the different tests of the plant. With all these certificates, the startup permit may be requested from the provincial administration, a permit that is usually granted in a relatively short time. Once all the fees are paid, the Regional Secretariat of Industry will give the green light for start-up, provided that all permits have been obtained from the relevant local authorities and approval is forthcoming from the provincial Planning and Environment Committee.The last requirement is to obtain permission from the distribution company to connect the PV plant to the network. This operation is carried out by technicians from the company or its affiliates. The distribution company must test the equipment and its operation, after a parameterization that allows them to perform meter reading via a modem. The local authority must also issue a license for the installation to open. The process ends with the signing of

agreements on compliance and a commitment to remain in operation for a minimum of 25 years, after which the ground will be returned to its initial state. A schematic diagram of the administrative process is shown in Fig. 7.

7. Conclusions

A preliminary analysis of the indicators used to calculate sustainability and the economic impact of different energy technologies are necessary to evaluate the project [12–14]. These indicators not only take into account purely economic factors, but social and environmental ones as well, such as the price of electricity, greenhouse gas emissions, availability and technological limitations, electricity generation efficiency, and environmental and social impacts.

The main argument to support the use of solar energy is that it represents a universally available, renewable energy source, which is not directly linked to political and environmental factors associated with the global market for oil and other fossil fuels. In the ranking of renewable energies drawn up by Evans [12], PV lags behind other renewable energies, due mainly to the low efficiency of current technology, which implies a higher price for electricity. The existence of feed-in tariff systems is an attempt to overcome this problem. It demonstrates institutional interest in encouraging the implementation of PV installations and has led to a proliferation of such plants, so much so that in the past two years, the price per kW installed has been reduced by almost half. Thus, the price of energy has been substantially lowered. If we consider improvements being made to all components at the plant, particularly the wiring, it is expected that the costs of this energy will soon be comparable to other renewable energies in a relatively short time. It is worth noting that even though the value of the premium has dropped by 40% this has not led to a decline in requests for new facilities.

Regardless of the sustainability indicators under discussion, the economic benefits of the project presented in this work are undeniable. As described in the section on costs and subsidies, the plant will have paid its costs over a maximum period of 8 years. The production bonus, which is part and parcel of the "solar farm", is guaranteed for 25 years, but if maintained the activity for at least the next 15 years, it ensures a premium of 75% of previous income. Therefore, is guaranteed a production bonus for 40 years; the entire working life of the installation. The plant will be dismantled in 2048, after having generated an income of about €34 million and production of 72,134 MWh. It will have avoided the emission of 219 T of CO_2 where the alternative is taken to be natural gas, or 396 in the case of coal.

All of the advantages outlined in this study are in stark contrast to problems that concern the administrative processing of permits in the various local and regional authorities, often motivated by ignorance and lack of coordination between separate bodies. A centralized procedure is clearly needed, which would facilitate the implementation of facilities and avoid delays and loss of competitiveness.

Acknowledgments

The present study was carried out under the research project BU019A08 supported by the Department of Culture and Education of the Regional Government of Castilla y León, Spain. The authors are also grateful for the cooperation offered by CIDESOL, the company responsible for the PV installation described in this article.

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